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IMPROVEMENT LINE PROCESS TO REDUCE PRODUCTION COST USING LEAN SIX SIGMA APPROACH

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Abstract — *According to the multidmensional economic crisis that impact on increasing drug prices, especially prices of patented drugs / trademark, these condition affect to the failure in fulfill of public health due to decreasing of purchase power. To cope these conditions required participation of the pharmaceutical industry especially in the manufacture to develop and socialize affordable drugs by all segments of civil society. This project aims to reduce the unit cost of products and that will directly affect the COGS product. Performed incrementally by selecting several products that provide the main value of PT. AAA. To analyze the causes and solutions to the problem, Six Sigma framework (DMAIC) was used which combined with the concept of Lean Manufacturing to eliminate non-value added processes called ―Lean Six Sigma". Lean Six Sigma is a methodology for improvement which can be used for all processes with the aim to achieve better conditions, faster, cheaper, and safer. Three products selected as pilot project for improvement of products. As-is condition indicates the number of waste were identified that affect the efficiency of the line process. The target of this improvement is to eliminate waste and improve line efficiency. From the results of root caused analysis, can implemented general and specific solutions for the three products. In this case, implementing 5S, work standardization, escalation system, autonomous maintenance, and vision performance system become the solutions. All solutions are implemented aimed to improve line efficiency and reduce man hours that could affect the cost reduction. Saving from this project in a year is IDR 226 million.*

Keywords: Unit Cost, Lean Six Sigma, Six Sigma, Lean Manufacturing, DMAIC

I. INTRODUCTION

Multidimensional economic crisis impact on increasing drug prices, especially prices of patented drugs / trademark, these condition affect to the failure in fulfill of public health due to decreasing of purchase power. To cope these condition required participation participation of the pharmaceutical industry especially in the manufacture to develop and socialize affordable drugs by all segments of civil society.

Additional with the global crisis in America and Europe which happen later, there was increase in pressure of the pharmaceutical industry competition that PT. AAA faces the challenge of making quality products at affordable prices.

PT. AAA founded on Jl. Sukabumi 61 Bandung on January 5th, 1971. At first PT. AAA is only the home industry that produces drugs in the simple form of syrup, capsules, tablets and ointments. In developing its business in 1977, PT. AAA expanding factory production sites. On July 27th, 1981, the plant division of PT. AAA moved to Jl. Simpang Raya 383 Padalarang. While its head office itself still remains on Jl. Sukabumi 61 Bandung. And right now, the head office are placed in Office 8 Senopati, Jakarta. For the next 4 years, Plant Division PT. AAA will develop the factory into a profit center to strengthen the system and utilization of plant and maintain the international quality standard certification in order to attract other companies to leverage partnership of AAA toll manufacturing at the factory.

The strategy map is the most important component to representation of the cause-and-effect relationship among the components of organization's strategy. Strategy maps are typically organized according to strategic themes. Organization should work toward creating strategy maps with a limited number of objectives and this should be the critical few processes that truly make a difference in delivering the strategy (James & Naresh, 2005).

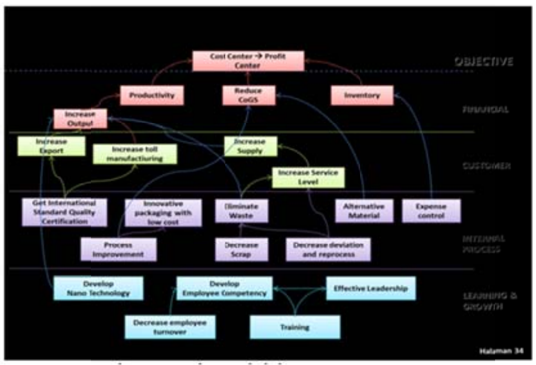

Figure 1. Plant Division Strategy Map

Based on the strategy map that was compiled in October 2011, to head the company's goal that is plant change from cost center to profit center there are three factors that support the achievement of these objectives, to increase productivity, to reduce Cost of Goods Sold (COGS), and to reduce Inventory.

Below is a resume of company's objectives in year 2011, and indicates the weight of each strategy:

Table 1. Company Objectives

Parameter	Target	Achievement (Jan – Sep 2011)	Weight
Productivity Index	86.35	46.79	20%
Cost of Goods Sold	Max 98% actual to standard cost	92.36%	25%
Days of Inventory : Packaging Material Raw Material Finished Goods	 81 days 75 days 31 days	 66 days 83 days 22 days	22.5%

It looks that in year 2011 the company's strategy was more concern in how to decrease the COGS in order to deliver both competitive price of goods sold and toll manufacturing fee offered to other company.

II. BUSINESS ISSUE EXPLORATION

A. Conceptual Framework

In the framework development of this project, which formed the initial rationale to see that business issues that arise in Plant Division of PT. AAA to achieve the company's strategy, that it was more concern in how to decrease the COGS in order to deliver both competitive price of goods sold and toll manufacturing fee offered to other company.

To analyze the causes and solutions to the problem, Six Sigma framework was used which combined with the concept of Lean Manufacturing to eliminate non-value added processes called "Lean Sigma".

Lean Six Sigma is a methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital. The fusion of Lean and Six Sigma is required because Lean cannot bring a process under statistical control and Six Sigma alone cannot dramatically improve process speed or reduce invested capital (George, 2004).

- Lean will identify things which do not have additional value (waste), with the ultimate goal of accelerating cycle time. The methodology was originally developed by Toyota to identify the 8 waste in production prosesses.
- Six Sigma aims to produce consistent output within tolerance (without variation).

In the application of six sigma there are five steps called DMAIC (Gaspersz, V., 2001) :

- Define: define the problem (problem statement), the scope, targets to be achieved, planning time and the formation of work teams.
- Measure: collecting all data and and related processes as well as establish a baseline of the project so that we can accurately compare the results of repair.
- Analyze: define and prioritize the root causes of problems that have a significant effect on productivity.
- Improve: choose the solution of the problem and show the differences before and after the improvement process.
- Control: ensure that implementation can be run well and sustainable.

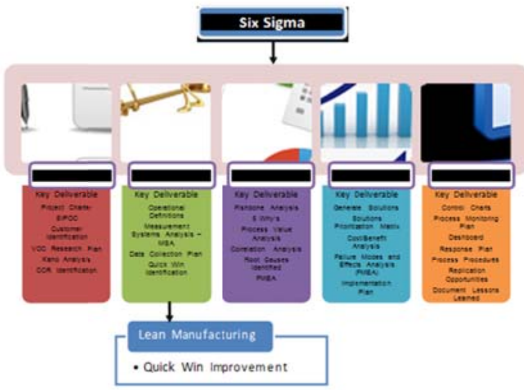

Figure 2. Conceptual Framework

B. Analysis of Business Situation

1. Business Situation

The growth of PT. AAA declined from the year 2009, this is a reference that there must be improvements in the system to increase the growth of the company. The market shares of 60 pharmaceutical companies as much as 84% while 139 companies have only 16% market share. This means most of the Indonesian pharmaceutical manufacturing companies operate on a small scale. Nevertheless Indonesian pharmaceutical market growth is relatively high (about 15% in 2004) and is the largest pharmaceutical market in ASEAN. AAA has become the 21th in the Indonesian market for its growth.

It has been identified that the real problem for the company was need improvement since the declining growth in 2009 and the fact that there was the very slow of new product release. This has been the key issue for PT. AAA. Average release time for new product was 2 years, where it should have been 1,5 year at maximum. Unfortunately this issue was worst by another problem of COGS that also need attention. In the high competition market, selling price is very important and COGS will be the main part in the final selling price decision. This is one that Plant Division can take initiative to decrease COGS which is a combination between cost of materials and cost of factory overhead.

At present, the composition of materials cost and FOH is about 60% and 40% meanwhile the company objective is bring the composition by 80% and 20% or reduce about 20% of factory overhead. This is big challenge for plant division where the high cost of FOH influenced by several factors such as sudden changes in the production schedule, machine breakdown that some time requires overtime.

2. Define

The first step taken for the identification problem is to identify Voice of Customer (VoC), which is define as an expression of willingness of customers, where customers are receiving products that made by the company.

Methods used to determine the VoC for this project is to capture data and internal discussions; the discussion was conducted in September 2011 by the internal management of the factory PT.AAA, and discussion of proficiency level translated into Critical Customer Requirements (CCR). CCR is the translation of data from the VoC into quantitative data.

From the CCR above, there are two group of requirements which will impact to lower down the cost of products:

1. Lower in the manufacturing cost.
2. Increase the output

Once the company identifies existing problems, they will specify the project which aligns to the objective. Currently PT. AAA has 193 products, which each with different COGS. It requires setting of specific target for each product to lower down the cost, starting with the pareto products. The pareto product can be obtained from several parameters, such as using production plan of the historical data, or product sales.

For product selection used pareto principle where a product is classified as class A products with a sales value of over than 2 billion rupiah. Selection using sales parameter was prepared by pareto diagram, where can be identified about 20% of products which contribute to about 80% of sales and each with 2 billion rupiah and above. Meanwhile the selection based on the frequency of production, using a year data of 2011 and production budget 2012. Comparing the both parameter, we can find the intersection products which can use as a parameter for priority selection for production during the next year period. As a project, there are 3 product selected whichrepresent the two types of preparation (liquid and solid) there are product OBU3, OBB1,and PTL2.

After that, the author try to make value stream mapping (VSM) from that product. Value Stream Mapping is created to see the bottle neck process in the entire production process for products OBU3, OBB1, and PTL2. That bottle neck process will be the main process to improved and make the flowing process more smoothly into the production process.
The next idea to develop this VSM diagram is to clearly shows those activities that add value, activities that do not add value, and steps that involve just waiting. By drawing a diagram that identifies the non-value-added activities and constraint process, we can understand what changes might have the biggest impact on leaning the process (Jacobs, et.al, 2009).

3. Measure

In measure phase we quantifies the current state of the process with respect to cost, speed and quality and provides an idea of the gaps to be filled. From VSM that has been made, we can measure how efficient a production line for product OBU3, OBB1, and PTL 2.

Table 2. Line Efficiency

Parameter	OBU3	OBB1	PTL2
Value added	62.5 hour	59.25 hour	78.3 hour
Non Value Added	160 hour	156.5 hour	167.8 hour
Cycle Time	222.5 hour	215.75 hour	246.1 hour
Line Efficiency	39%	38%	47%

Analysis

The aim of the analyze phase is to establish the root cause and prioritize the problems. The main step in the Analyze phase is to identify bottle necks and constrain step in a process and takes into account the impact in productivity. In this project, after created value stream mapping process, we can determine where the constrain step in the process.

OBU3

For OBU3 product, the constraint (bottle neck) is in phase packing, so the first step taken is to analyze the cause of the constraint. OBU3 packaging process is one of a series of liquid processes that exist in PT. AAA. Based on the data collected during the process, it found the problem is not optimal Liquid packing process of OBU3. At liquid packaging process of OBU3 still found a few steps that less effective so we can do some improvements.

From the results of the identification and measurement problems, then the team do the brainstorming to determine the root caused from working hour in packing process that do not lean and become a bottle neck in the production process. Brainstorming results poured in isikhawa diagram (fishbone) below :

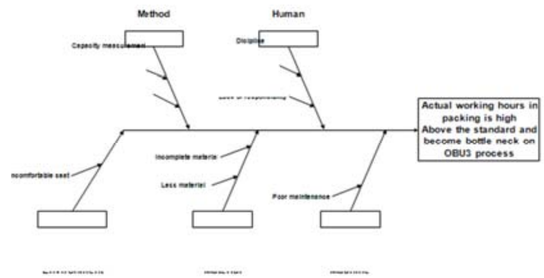

Figure 3. Isikhawa Diagram for OBU3

From some of the probable root caused was determine some major problems that caused the actual working hours is very high in packing and become a bottle neck.

Table 3. Cause and Effect Problems in Packing OBU3

No.	Factor	Probable Caused	Effect
1	Human	Operator ease in working on his job	Actual working hour is high
	Why1?	Because the operator does not know the target outputs and activities to do	operator works according to their own desires
	Why2?	Because the operator is not shared with the standard working hours and no standard activity	operator does not know the target output
2	Machine	Machine breakdown frequently	High total unplanned downtime machine
	Why1?	Implementation of maintenance planning is not update	Operator does not know about machine condition
	Why2?	Maintenance planning is not executed as scheduled by the engineering	

OBB1

For OBB1 product the process constraint is in filling stage, where we can see that the actual hours of filling process is higher than the mixing process. Based on the data collected during the process, it found the problem that is not optimal Filling Machine Vectra for OBB1 with a capacity of filling an average of only 4,850 bottles perhour compared to the installed machine capacity is 6,950 bottles per hour, so it needs to do some improvement to maximize the machine utilization.

From the results of the identification and measurement problems, then the team do the brainsorming to determine the root caused from working hour in packing process that do not lean and become a bottle neck in theproduction process. Brainstorming results poured in isikhawa diagram (fishbone) below :

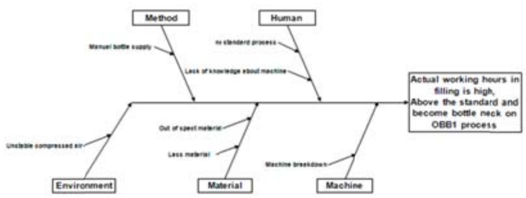

Figure 4. Isikhawa Diagram for OBB1

From some of the probable root caused was determine some major problems that caused the actual working hours is very high in filling process and become a bottle neck.

Table 4. Cause and Effect roblems in Filling OBB1

No.	Factor	Probable Caused	Effect
1	Machine	machine are often stopped	Actual working hour filling process is high (compared to machine capacity)
	Why1?	Because many bottles falls	Bottles are wedged
	Why2?	Because bottles are used for OBB1 is plastic bottles	Low cost
	Why2*?	Because bottles does not fit to machine	
	Why3?	Because the product is already registered to use plastic bottles	
	Why3*?	Because the machine is design for glass bottles	

For PTL2 product, process constrain is in stripping stage, where the stripping working hours (27.50 hours) is the highest compared with other processes. PTL2 is one solid product that formed film coating caplet and strip primary packaging. Primary packaging process (stripping process) PTL2 using NR2 machine that sometimes happened a problem, as the strip is less neat, caplets are broken, and others. This leads to increased working hours in stripping process. Therefore, the necessary to improve the stripping process of PTL2 products more quickly so doesn't impede the flow process to the next process (secondary packaging). From the results of the identification and measurement problems, then the team do the brainstorming to determine the root caused from working hour in packing process that do not lean and become a bottle neck in the production process. Brainstorming results poured in isikhawa diagram (fishbone) below :

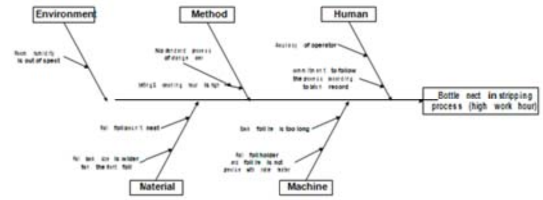

Figure 5. Isikhawa Diagram for PTL2

From some of the probable root caused was determine some major problems that caused the actual working hours is very high in stripping process and become a bottle neck.

Table 5. Cause and Effect Problems in Stripping PTL2

No.	Factor	Probable Caused	Effect
1	Human	Output uncontroled periodically	Afkir materials wasn't controled and restripping, Actual working hour is high
	Why1?	Because there is a sorting process	Non value add activity
	Why2?	Because the strip is not flat according to specifications	operator have to cutting the strip manually
	Why3?	Because machine and material	
2	Machine	20% output from machine is out of spesification	reopening of the strip and restripping
	Why1?	Roll foil holder and foil line is notprecise with roller heater	Unstable back foil position and High hour of setting machine
	Why2?	Back foil line is too long	
3	Material	Roll foil doesn't neat	the strip should be cut manually
	Why1?	Because back foil size is wider than front foil	the shifting position of the foil at the time of spinning reels
	Why2?	because of variations in the size of the foil (there is range on the specification)	

III. BUSINESS SOLUTION

A. Alternative of Business Solution

Based on result of root caused analysis in the previous chapter, the lean six sigma project for OBU3, OBB1, and PTL2 products was faced several constraints in the process. Each product have specific and general obstacle. But this project can use the basic tools in Lean Manufacturing to minimize non-value added processes and prevent the common problems to. Continuing succesful operation of Lean Manufacturing requires a commitment to seek continous improvement during transformation process and it will require changing the company culture (Hobbs, 2004).

Table 5. Lean Manufacturing Tools

Caused	Factor	Tools	Applied to
operator is not shared with the standard working hours and no standard activity (OBU3)	Human	5 S	OBU3
		Work Standardization	
Output uncontroled periodically (PTL2)		Shopfloor Interval Control (SIC)	OBB1
Maintenance planning is not executed as scheduled by the engineering (OBU3)	Machine	Autonomous maintenance	PTL2
machine are often stopped (OBB1)		Scoreboard and Scoresheet	

B. Analysis of Business Solution

In general, business solution required by PT. AAA in the implementation of Lean Six Sigma project is the application of basic systems as an alternative solution in solution in the business. So the obstacles faced by the product of OBU3, OBB1, and PTL2 can be solved in a specific way.

1. Quick Improvement

Using the value stream mapping we can identify existing waste. After identification then we can be classified be classified into 8 wastes. Waste or younger is a traditional Japanese term or wastefull activities and do not have any additional value. Decline in youth is an effective way to increase profits of the company.

a. Waste of Transportation
   Waste of transportation is the transportation which have no changes to the product in accordance with the consumer expectation.
b. Waste of Inventory
   Inventory in the form of raw materials, work in process (WIP), and finished goods that increase the expenses and not generating revenue yet.
c. Waste of Motion
   Waste of motion include the movement of workers or equipment that do not add value to the operation of production process.
d. Waste of Waiting
   Waste of waiting cover the whole time which needs to make the process stop, such as when waiting arrival of raw materials, information, tools, equipment until the form of capital goods and services that have not been given yet to the consumer.
e. Waste of Over production
   Over production is to make products with higher numbers, more than consumer demand or exceeds the amount needed.
f. Waste of Over processing
   Over processing includes all activities in the production process that should not need to exist and is not necessary that only adds to the cost of production.
g. Waste of Defects
   Waste of defect is a quality defect that occurs in the process and final which will block the delivery of goods to consumers and there are additional man power, energy,and materials.
h. Waste of nderutilized People
   Underutilized people is a waste because workers do not spend all of its capabilities. This refers to the waste of administrative disconnectedness within a company and or its suppliers and customers. Such disconnection are barriers to creativity, innovation and knowledge that can create excess costs, missed opportunities and frustation.

OBU3

The results of root cause analysis in the previous chapter indicate that the constraint in the production process of OBU3 is in the packing process where some of the main factors as below:

Table 6. Business Solution for OBU3

Factors	Cause	Business Solution
Human	operator is not shared with the standard working hours and no standard activity	Scoresheet, Work standardization, build a team work, line balancing
Machine	Maintenance planning is not executed as scheduled by the engineering	Autonomous Maintenance, 5S and Visual Management

OBB1

The results of root cause analysis in the previous chapter indicate that the constraint in the production process of OBB1 is in the filling process where some of the main factors as below :

Table 7. Business Solution for OBB1

Factors	Cause	Business Solution
Machine	Machine breakdown	Autonomous Maintenance

PLT2

The results of root cause analysis in the previous chapter indicate that the constraint in the production process of PTL2 is in the stripping process where some of the main factors as below :

Table 8. Business Solution for PTL2

Factors	Cause	Business Solution
Human	Output uncontroled periodically	Scoresheet
Machine	Back foil line is too long	5 S and Visual Management, Autonomous Maintenance
Materials	variations in the size of the foil (there is range on the specification)	5S and Visual Management, Built a Teamwork

IV. CONCLUSION AND IMPLEMENTATION PLAN

In order to guide the team to accomplished the project with a good improvement and structured, it needs to make project time line and budget to implement those improvements.

1. Control

In the control phase, once the solution has resolved the problem, the improvements must be standardized and sustained over time. The Standard Operational Procedure (SOP) may require revision, and a control plan should be put in place to monitor on going performance. The project team transitions the standardized improvements and sustaining control plan to the process players and closes out the project. That SOPs set the stages that need to be done by operators and related personnel.

The SOPs that been made are :

a. Lean Manufacturing Standardization Program
b. 5S Standardization Program
c. Autonomous Maintenance Standardization Program
d. Work Standardization after Improvemet

2. Total Benefit From Improvement

Table 9. Line Efficiency

Parameter	OBU3	OBB1	PTL2
Value added	58.5 hour	56.75 hour	74.8 hour
Non Value Added	135 hour	134 hour	134 hour
Cycle Time	293.5 hour	190.75 hour	208.8 hour
Line Efficiency	43%	42%	56%

Table 10. Benefit from Improvement OBU3

Parameter	Before Improvement	After Improvement
Output per hour	4,571 bottles	6,622 bottles
Lead Time	16 hours	13 hours
#Worker	30 people	22 people
Man Hour	480 Man hour	286 Man hour
Productivity	10 bottles/man hour	23 bottles/manhour
Cost Saving		IDR 54,000,000

Table 11. Benefit from Improvement OBB1

Parameter	Before Improvement	After Improvement
Output per hour	4,850 bottles	5,500 bottles
Lead Time	17 hours	14.5 hours
#Worker	11 people	11 people
Man Hour	187 Man hour	159 Man hour
Productivity	26 bottles/man hour	35 bottles/manhour
Cost Saving		IDR 40,329,200

Table 12. Benefit from Improvement PTL2

Parameter	Before Improvement	After Improvement
Output per hour	1,091 strips	1,250 strips
Lead Time	27.50 hours	24.00 hours
#Worker	2 people	2 people
Man Hour	55 Man hour	48 Man hour
Productivity	20 strips/man hour	26 strips/manhour
Cost Saving		IDR 132,160,000

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